of Agriculture in Nancy. "The main proof of this is that rabbits and the myxoma virus are not native there. So, if the rabbit and virus have traveled to Australia, you could say their return ticket has already been bought."

The researchers at the VBC contend, however, that while myxoma proved a faulty weapon in their earlier rabbit wars, it has never escaped—not even to New Zealand. Nor has the virus ever infected species besides rabbits and hares. Researchers contend that new myxoma strains have tremendous difficulty establishing themselves in new areas and that they tend to be pushed out by local varieties. Hugh Tyndale-Biscoe, the director of the VBC, believes that the team's "biggest problem will actually be getting the thing to take in the rabbit, not stopping it."

But playing with animal populations raises questions that go beyond concerns about researchers' ability to control a virus. Even with immunosterilization, the foxes will only reach a certain reduced population level—although what that level might be, and whether it will be low enough to stimulate a resurgence of marsupials, is currently unknown. That leads to another worry. In some habitats, foxes live in groups that have several females, but only the dominant female breeds. What if the sterilization somehow alters the foxes' social structure so that subdominant females begin bearing litters? Would that trigger a population boom, following the initial bust?

Such unanswered questions make the Australian plan a gamble. In the hopes of reducing the odds, and further understanding the animals' reactions to population flux, the researchers have begun field experiments using surgically sterilized animals to mimic the hoped-for effects of the immunocontraceptives. But they have every intention of going forward with the program once the data come in and GMAC gives its approval. By 1995, they hope to have permission to put the recombinant virus in a lab rabbit for testing.

If the doubters can be silenced, and the scheme works, then it might be adapted for controlling non-native species that are devastating environments such as Hawaii, where feral pigs are wreaking havoc, and New Zealand, where introduced possums are causing trouble. The U.S. Department of Agriculture is cosponsoring an international conference on immunocontraception in wildlife management in Denver in October; the Australians will be there to present their research. But if the plan doesn't work, and pest populations start to explode after crashing or the virus gets out from down under, Australians could be facing a new ecological crisis just as severe as the one they're trying to end.

–Virginia Morell

COSMOLOGY

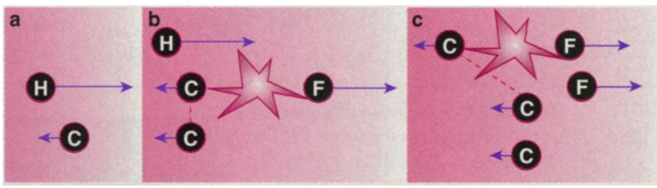
Hot and Cold Dark Matter on Tap

Lately, cosmologists have been turning the birth of the universe into a computer video game. They populate space with various sorts of particles, set the cosmic density and other parameters, then run a movie of the Big Bang and the subsequent expansion. The winning simulation is the one that blows up to look something like the observed cosmic macrostructures—"walls" and "filaments" of galaxies—and does so with as few never-before-seen particles or other arbitrary, ad hoc ingredients as possible. Now a team from the Canadian Institute for Theoretical Astrophysics has devised a way to boost the standing of a favorite strategy.

The innovation involves a modification of a key ingredient of the simulations: "dark matter," hypothetical, invisible particles that contribute their gravitational pull to creating structure in the universe. Many cosmologists can swallow the idea of one type of mystery particle, but the simulation that comes closest to recreating the structures seen in today's universe requires not one but two types of dark matter: "hot" particles that move near the speed of light and "cold" particles that move far more slowly. In this week's *Physical Review Letters* Nick Kaiser, Robert Malaney, and G. Starkman propose a remedy for this distasteful requirement: They add just one mystery particle, which does the job by spontaneously breaking down in two stages to create a hot and cold cosmic cocktail.

To get the needed bang out of a single particle, it has to be both massive and unstable. The original candidate of such a monster emerged in 1991, when several groups thought they saw signs of a new kind of neutrino, with a mass of 17 kiloelectron volts instead of the unmeasurably small mass of ordinary neutrinos (Science, 18 December 1992, p. 258). Cosmologist Jes Madsen of the University of Aarhus suggested that this particle might break down into hot and cold dark matter.

By now, "the 17 kev neutrino is dead," admits Kaiser. But that doesn't mean that some type of heavy neutrino is out of the question. His group speculates that the newborn universe was aswarm with massive neutrinos that, within the first second after the Big Bang, could have broken down in two steps, the first step creating the cold matter, the second, the hot.



Chain reaction. In the newborn universe, the cold dark matter particles (C) released—along with a byproduct (F)—by the decay of heavy neutrinos (H) might have triggered successive decays.

The first step is called "neutrino lasing" because it creates cold particles in a chain reaction analogous to the way a laser makes photons. In a laser, a group of atoms must be pumped into an energized "excited" state. When one randomly breaks down to a more stable form, it emits a photon that triggers other atoms to break down. As this cascade continues it ultimately releases many photons with precisely the same energy. In neutrino lasing, the heavy neutrino acts as the excited atom, and it breaks down into a more stable neutrino-like particle and a hypothetical dark matter particle, of unspecified type, which like a laser's photons triggers emission of more dark matter particles.

The lasing step emits dark matter of the cold variety, explains Kaiser, for the paradoxical reason that the newborn universe is so hot that the heavy neutrinos move at close to the speed of light. When the fast neutrinos decay, "the situation is rather like what would happen if one exploded a grenade on the back of a rapidly moving truck." To an observer on the roadside, he says, the grenade fragments that sprayed out behind the truck might appear to move much slower than the truck itself.

The lasing makes all the particles come out with the same energy as the one that sets off the cascade, so one cold particle could produce a whole swarm of clones. The hot matter comes out later, when the universe cools too much to sustain the remaining population of heavy neutrinos. These break down, without lasing, into hot dark matter.

This two-stage scenario, says Fermilab cosmologist Michael Turner, is "a very cute idea." But he points out that the best mixed dark matter models require a 70-30 mix of cold to hot matter, while the Canadians' recipe yields at most a 50-50 ratio. And Turner says he isn't even sure of the premise of mixed dark matter in the first place. Turner prefers unadulterated cold dark matter—which doesn't come out quite as well in the simulations but is simpler, requiring fewer fancy ingredients and preparation methods. Besides, he says, it might be close enough. "We've learned over the last decade," he says, "that computer simulations are less reliable than we thought."

–Faye Flam